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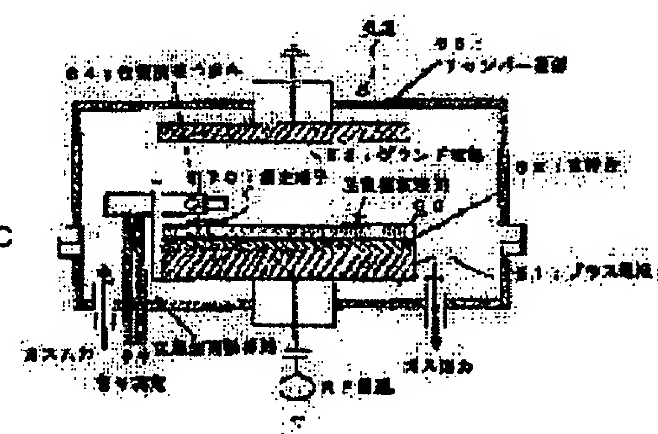
(54) CENTER FREQUENCY ADJUSTMENT METHOD FOR SURFACE ACOUSTIC WAVE DEVICE AND PRODUCTION OF THE DEVICE

(57)Abstract:
PROBLEM TO BE SOLVED: To easily adjust the center frequency of an SAW(surface acoustic wave) filter by measuring the input/output characteristic including the frequency characteristic of an SAW device and repeating both etching and oxide forming steps until the desired input/output characteristic is obtained.
SOLUTION: A piezoelectric substrate 50 is placed in a chamber 52 having a terminal 70 which can measure the input/output characteristic including the frequency characteristic of an SAW device. In an etching step, the surface of an interdigital electrode constructing the SAW device is shaped by a method such as the dry etching. In an oxide forming step, an oxide is formed on the surface of the interdigital electrode. In a repeating step, the input/output characteristic including the frequency characteristic of the SAW device is measured via the terminal 70. Then both etching and oxide forming steps are repeated until the desired input/output characteristic is obtained.



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CLAIMS

[Claim(s)]

[Claim 1] In the resonator mold surface acoustic wave filter constituted by the ladder mold circuit which consists of a serial arm surface acoustic wave resonator and a juxtaposition arm surface acoustic wave resonator using the surface acoustic wave resonator which changes the surface acoustic wave into an electrical signal after being prepared on a piezo-electric substrate and changing an electrical signal into a surface acoustic wave two or more The resonance frequency or antiresonant frequency of said serial arm surface acoustic wave resonator is measured. Put an insulator layer on this serial arm surface acoustic wave resonator by the comparison with the measurement result and said resonator mold surface acoustic wave center of filter frequency, or perform etching processing, and the resonance frequency or antiresonant frequency of this serial arm surface acoustic wave resonator is adjusted. The antiresonant frequency or resonance frequency of said juxtaposition arm surface acoustic wave resonator is measured. Putting an insulator layer on this juxtaposition arm surface acoustic wave resonator by the comparison with the measurement result and said resonator mold surface acoustic wave center of filter frequency, or performing etching processing, and adjusting the antiresonant frequency or resonance frequency of this juxtaposition arm surface acoustic wave resonator The frequency regulation approach of the resonator mold surface acoustic wave filter by which it is characterized.

[Translation done.]

【인용발명 2: 일본공개특허공보 평12-156620호(2000.06.06) 1부.】

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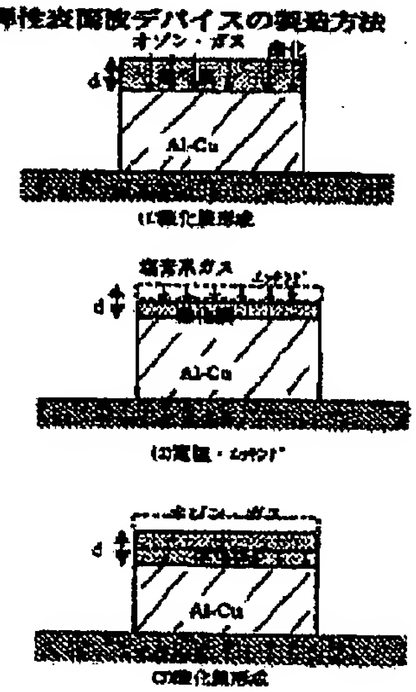
(54)【発明の名称】 弾性表面波デバイスの中心周波数調整方法および弾性表面波デバイスの製造方法

(57)【要約】
【課題】 SAWデバイスの中心周波数の調整を、SAWデバイスの製造工程中に行う。
【解決手段】 RIE装置チャンバー内にオゾンガスを導入し、内部温度（150℃～200℃程度）を制御することで、酸化膜dを形成する。形成後、RF測定により中心周波数測定を行い、目的の周波数の得られるエッチング量（切削膜厚）を決定する。チャンバー内のガスを塩素系ガスと入れ替えを行い、RIE装置のガス濃度、RFパワー、エッチング時間等を制御し目的の膜厚までエッチングを行う。エッチング厚みは上記形成した酸化膜の膜厚以内にする。再びチャンバー内にオゾンガスを導入し酸化膜形成を行う。この酸化膜の形成は、RIEで切削した電極膜厚分の酸化膜厚を補う目的で行われる。この酸化膜の形成で得られる酸化膜は、最初に形成した酸化膜厚と同じ膜厚とする。中心周波数が所望の値になるまで、酸化膜の形成とエッチングとを繰り返す。



【特許請求の範囲】

【請求項 1】 圧電基板上に形成された弾性表面波デバイスを製造する際に前記弾性表面デバイスの中心周波数を調整する方法において、
当該弾性表面波デバイスの周波数特性を含む入出力特性を測定可能な端子を有するチャンバー内に前記圧電基板を配置する配置ステップと、
前記弾性表面波デバイスを構成する交差指状電極の表面をドライエッチング等の方法を用いて削るエッチングステップと、
前記交差指状電極の表面に酸化物を形成する酸化物形成ステップと、
前記端子を介して前記弾性表面デバイスの周波数特性を含む入出力特性の測定を行い、所望の特性が得られるまで、前記エッチングステップと前記酸化物形成ステップとを、繰り返し実行する繰り返しステップと、を含むことを特徴とする弾性表面波デバイスの中心周波数調整方法。

【請求項 2】 請求項 1の方法を用いた弾性表面波デバイスの製造方法。

【請求項 3】 請求項 1の方法を用いて製造された弾性表面波デバイス。

【請求項 4】 請求項 1の方法を用いて製造された弾性表面波デバイスを利用した通信装置。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、ＳＡＷ（弾性表面波）デバイスに関する。特に、そのＳＡＷデバイスの中心周波数を、製造工程中に調整する方法に関する。

【0002】

【従来の技術】ＳＡＷデバイスは、周波数フィルタとして広く利用されている。本願発明者らは、その共振周波数をより狭帯域化した水晶基盤を用いたフィルタを開発している。

【0003】この開発している高周波狭帯域フィルタは、水晶基板上のS.TW（Surface Transverse Wave）を利用した高Ｑ共振器フィルタであり、その表面弾性波の音速は、５１００ｍ／ｓ程度であり、従来のデバイスに比べて高速、高周波化に適している。この開発しているデバイスの負荷Ｑ値は、およそ１５００程度である。また、このＳＴＷデバイスは、水晶基板を用いているため、従来のＳＡＷデバイスの周波数温度依存特性－１８ｐｐｍ／℃に対して、１～４ｐｐｍ／℃程度の周波数温度特性を呈する。その結果、開発したＳＴＷデバイスは、１００℃の温度範囲に対して、周波数変動が約１００ｐｐｍ（０．０８ＭＨｚ）程度となる。

【0004】高いＱ値を有しているため、この開発したＳＴＷデバイスは、例えば８００ＭＨｚ帯フィルタでは、その通過帯域幅は従来２．４ＭＨｚ程度であったのに対して、０．５ＭＨｚ程度となる。すなわち、従来のＳＡＷデバイスに対して超狭帯域化が達成されている。なお、開発したＳＴＷデバイスの比帯域幅は０．０７％である。また、帯域外減衰量は、従来のデバイスが中心周波数の±２ＭＨｚで２０ｄＢであったのに対して、同じく中心周波数の±２ＭＨｚで３５ｄＢとなり、大幅な改善が実現されている。又、この開発したＳＴＷデバイスは高いＱ共振器としてＶＣＯ等への応用も可能である。

【0005】弾性表面波の音速が速いため、開発したＳＴＷデバイスにおいては、１ＧＨｚの信号を扱うもので電極線幅１．３μｍ程度である。したがって、現在の電極加工技術の下では、信号周波数として１～２ＧＨｚ程度までを扱えるフィルタの製造が可能である。

【0006】しかし、本願発明者らが開発してきたこのＳＴＷデバイスでは、高いＱ値、狭い通過帯域幅のため、電極指線幅、電極膜厚等の出来上がり寸法バラツキが問題となった。特に電極膜厚バラツキによるフィルタの中心周波数の変動は製造歩留まりを大きく低下させる結果となった。

【0007】このＳＴＷデバイスの電極膜厚による中心周波数の感度は０．２ＭＨｚ／１０オングストローム程度である。又、Ａｌ（アルミニウム）蒸着装置製造精度は３０オングストローム～６０オングストローム程度である。その結果、中心周波数は最大１．２ＭＨｚ程度変動してしまう可能性がある。従来のＳＡＷフィルタでは、このような中心周波数の変動は、多少歩留まりに影響する程度であるが、新しく開発した水晶ＳＴＷフィルタでは中心周波数の変動の結果、通過帯域が全く別物になってしまう恐れもある。したがって、目的の周波数特性が得られるフィルタが１ウェハー内（又は１バッチ内）に１個も存在しないという事態も十分に想定される。

【0008】したがって、本願発明者らは、新たに開発したＳＴＷデバイスに関して、これまでは問題にされなかった蒸着装置の限界加工精度、製膜バラツキ状態（電極膜厚、電極指線幅）による中心周波数の変動を調査し、その中心周波数を調整する技術を確立する必要が生じたのである。

【0009】ＦＤＢ製造方式

図５には、従来のＦＤＢ方式のＳＡＷフィルタ製造方法を表す説明図が示されている。ＦＤＢ方式は、ＳＡＷチップ入出力パッドとＳＡＷチップ１０を収納するパッケージ１２の内部に形成されたパターンを向かい合わせ金バンプ１４を介して接続し、電気的な接続と機械的な保持を同時に行う製造方法である。

【0010】この製造方法は接着剤等を用いることがないため、パッケージ内部状態が安定で、前述の水晶ＳＴＷフィルタを含む種々の狭帯域ＳＡＷフィルタの製造に適している。又、ＳＡＷデバイスを小型化できるため、量産品種に多く用いられている。

【００１１】現状の製造方法及び中心周波数の調整方法ＳＡＷフィルタの製造工程は、前半のウェハー・プロセスと、後半のアッセンブリー・プロセスに大きく分けることができる。この製造工程を表すフローチャートが図６に示されている。

【００１２】ウェハー・プロセス２０では圧電基板上に電極パターン、パッドパターン形成、その他基板表面処理等を行う。レジスト塗布は、ステップＳ６－１において行われ、露光及び現像は、ステップＳ６－２及びステップＳ６－３において行われる。また、Ａｌ蒸着は、ステップＳ６－４において行われる。さらに、リフト・オフ作業はステップＳ６－５において行われる。これらの各処理は、パターン毎に行われる。

【００１３】電極パターンの蒸着膜厚はフィルタの周波数特性に直接的に影響するため、膜厚の制御は重要である。数千オングストローム ±４０オングストローム の高精度で形成する技術が知られている。従来のＳＡＷデバイスにおいては、通過帯域幅が２．４ＭＨｚ程度であり、製造歩留まりは悪いが周波数調整の必要性は少なかった。しかし、本発明者らが開発している上記水晶ＳＴＷフィルタでは、極めて狭通過帯域が実現されているため、周波数を調整するための工程が製造工程に含まれなければならない。

【００１４】ステップＳ６－６においては、中心周波数ｆ０の検査が行われ、中心周波数ｆ０の調整が必要であると判断される場合には、ステップＳ６－７において中心周波数ｆ０の調整が行われる。そして、ステップＳ６－８において、バンプ形成が行われる。

【００１５】次に、アッセンブリー・プロセス２２ではＳＡＷチップの組立が行われる。ダイシングが、ステップＳ６－９において行われる。また、チップ洗浄がステップＳ６－１０において行われる。また、パッケージ詰め等のＦＤＢの処理がステップＳ６－１２において行われる。最後にシーリング処理がステップＳ６－１３において行われる。

【００１６】最終的な製品の検査がステップＳ６－１４において行われ、検査に合格したものが出荷される。

【００１７】以上述べたように、図６は、水晶ＳＴＷフィルタの製造工程を示したフローチャートであり、従来のＳＡＷの製造工程にＲＦプローバ測定工程及びｆ０調整工程が付加されている。上述したｆ０調整はＲＩＥ装置（ドライエッチング）又は現像装置（ウェット・エッチング）で行なわれる。工程が増えるため、製造コストは増加する。

【００１８】周波数調整は１ウェハー毎に行う。１チップ毎行うことは現在のところ困難である。周波数の調整は、１ウェハー内の全てのチップの電極又は圧電基板表面を微少に削ることによって行われる。調整装置はリアクティブ・イオン・エッチング（ＲＩＥ）装置が最も精度が良く、製造バラツキが少ない。この装置は、塩素系ガスを用いて電極材料（Ａｌ－Ｃｕ）を削る方法で周波数調整を行う。ウェハー・プロセス２０において、レジストを現像する装置を流用し、ウェット・エッチングを行って電極表面を削る方法もある。この方法は製造精度バラツキなどは大きいが、簡易であるため、実際の現場ではこの装置を用いて周波数調整を行っている場合が多い。

【００１９】上記ＲＩＥ装置は精度の良い周波数調整に適している。この装置の問題点はエッチングレイトを何処まで落とせるかである。一方、ウェット・エッチングは調整の均一性や再現性に関して劣るが、上述した理由によって実際はウェット・エッチング装置を用いて数１０オングストローム ～１００オングストローム 程度電極を削り、最大２ＭＨｚ程度の周波数調整を行っている。

【００２０】さて、以上述べたように、圧電基板上に形成されたＳＡＷデバイスの中心周波数調整技術としてウェット・エッチング又はドライエッチング技術があった。

【００２１】例えばＡｌ（アルミニウム）のウェット・エッチングにはフッ酸、硝酸等を希釈したエッチング液を用いる方法が一般的である。微量なエッチングをするには有機アルカリ系現像液を用いることもできる。電極材料をエッチングすることで電極厚みを薄くし、素子の中心周波数を高めている。

【００２２】また、ドライエッチングとしては、リアクティブイオンエッチング（ＲＩＥ）技術が広く利用されている。高周波電界内で電極材料と塩素ガス系を反応させる。電極材料をエッチングすることにより中心周波数を高めることができる。

【００２３】

【発明が解決しようとする課題】さて、弾性表面波デバイスが８００ＭＨｚ帯以上に高周波化されると、ＩＤＴ電極幅は１μｍ、電極膜厚は１００ｎｍ以下と狭くなり、さらに、１０オングストローム 程度以下の膜厚制御技術が必要となる。この場合、電極の加工精度がデバイスの中心周波数に影響する。さらに、電極表面の酸化現象にも注意を払う必要がある。その理由は、酸化膜の厚みがデバイスの中心周波数に影響するからである。さらに、周波数をより正確に調整する技術も望まれている。

【００２４】また、酸化現象は徐々に進行するため、ウェハー上での中心周波数測定は上記酸化膜の安定した状態で実行しなければならない。不安定なまま測定を行うと、組立工程後の酸化現象によって測定時と製品出荷時とで中心周波数が変化してしまうことも想定される。

【００２５】上述した従来技術の製造方法、周波数の調整方法は、ウェット（ドライ）エッチング作業→中心周波数測定の単一工程であり、作業の性格上繰り返し行うものではない。エッチング量の制御の正確さが必要となる。

【００２６】特にウェット・エッチングはエッチング液

に基板を浸食させるため、制御性が悪い。還元すれば、周波数変化が大きく、中心周波数を所望の周波数に合わせる作業が困難である。又、酸化膜の形成についてはなんら考慮されていないため、中心周波数の経年変化が生じる可能性がある。具体的には、以下のようなことがいえよう。

【００２７】ＳＡＷフィルタの電極指はＡｌ－Ｃｕを真空蒸着する方法で形成されている。Ａｌは空気中の酸素と化学反応し、酸化化合物となる。酸化化合物の厚みは時間とともに徐々に増加し、デバイスの周囲温度で決定されるある厚みに達するとそれ以上進行しない。この厚みは、数オングストローム～１００オングストロームと思われる。

【００２８】上述したように、ＳＡＷフィルタの製造後、この酸化反応が徐々に進行し、電極表面の酸化膜厚が変化する。酸化物厚みが変化するとフィルタの中心周波数もずれてしまう。従来の技術においては、この酸化膜の特性への影響を考慮する必要のある製品は少なかったが、ＳＡＷフィルタの狭帯域化が進行するにしたがって、かかる特性への影響を考慮した中心周波数の調整手法が望まれている。

【００２９】本発明は、上記課題に鑑みてなされたものであり、その目的は、ＳＡＷフィルタの中心周波数を容易に調整でき、かつ、中心周波数の経年変化が少ない中心周波数の調整方法を提供することである。

【００３０】

【課題を解決するための手段】本発明は、上記課題を解決するために、ｆ０調整を、ＲＩＥ装置を利用して塩素系ガスを用いてＡｌ－Ｃｕ電極をエッチングすることにより行っている。そして、本発明は、酸化膜の影響を考慮した新しい周波数調整方法を提案するものである。

【００３１】前述したように、膜厚に対する中心周波数の変動は０．２ＭＨｚ／１０オングストローム程度の感度がある。数＋オングストローム程度、酸化膜の厚みが変化しても、その影響で微妙に中心周波数がずれてしまう。また、酸化膜厚の制御・管理をせず酸化膜を自然形成させると、中心周波数が経年変化し、デバイスの信頼性に大きな影響を与える。又、電極エッチング時に、酸化膜層とアルミ層を跨ってエッチングを行うと、材料の性質が異なることからエッチングレイトが変化し、正確なエッチングが困難となっている。

【００３２】経年変化を防止するためには、電極の酸化膜を意図的に形成してしまうのが最も簡単な解決法である。酸化膜を形成するにはオゾンガス中にて基板温度を上げる方法が好ましい。上記ＲＩＥはチャンバー内でガスと反応させる方式であるため、ガスをオゾンと入れ替えることで容易に酸化膜の形成が可能である。しかも同バッチ内で作業でき、製造工程上好ましい。

【００３３】図１にはＲＩＥエッチング製造チャンバー内部に配置されたＳＡＷフィルタの電極指について、その断面を拡大表示した図が示されている。

【００３４】図１（１）には、酸化膜の形成についての説明図が示されている。まず初めにＲＩＥ装置チャンバー内にオゾンガスを導入する。チャンバー内部温度（１５０℃～２００℃程度）を制御することで、デバイスの使用環境温度で決まる自然酸化膜厚以上の酸化膜ｄを予め形成する。形成後、ＲＦ測定により中心周波数測定を行い、目的の周波数の得られるエッチング量（切削膜厚）を決定する。

【００３５】次に、図１（２）において、チャンバー内のガスを塩素系ガスと入れ替えを行い、ＲＩＥ装置のガス濃度、ＲＦパワー、エッチング時間等を制御し目的の膜厚までエッチングを行う。エッチング厚みは図１（１）で説明した酸化膜の形成で作成した酸化物膜厚以内にする。それ以上の切削が必要な場合は、図１（１）、及び図１（２）から次に述べる図１（３）までの工程を繰り返し行う。

【００３６】次に、図１（３）においては、再びチャンバー内にオゾンガスを導入し酸化膜形成を行う。この酸化膜の形成は、ＲＩＥで切削した電極膜厚分の酸化膜厚を補う目的で行われる。この酸化膜の形成で得られる酸化膜は、上述した図１（１）で説明した処理において形成した酸化膜厚と同じ膜厚とする。その結果、チャンバー外にデバイスを取り出して、放置しても電極エッチング後のデバイスの中心周波数の変動を防止することができ、調整した中心周波数は維持される。

【００３７】以上の方法で電極酸化膜影響を留意した電極エッチング、中心周波数調整、を行うことができる。

【００３８】又、目的の中心周波数に調整できなかった場合、更に正確に調整する場合、酸化膜厚以上にエッチングする場合、等においては、前記図１（１）乃至図１（３）の操作を再度繰り返し行うことが好ましい。

【００３９】又中心周波数を上げるだけでなく、反応ガスをフッ素系に入れ替えて、水晶基板表面をエッチングすれば、中心周波数を下げることができる。フッ素系ガスで水晶基板表面をエッチングする場合は、電極酸化膜厚は変化しないため、再度酸化膜を形成する必要はない。つまり、図１（１）及び図１（３）で説明した処理工程は実行せずに図１（２）で説明した処理工程で反応ガスを塩素系ガスからフッ素系ガスに変更し、目的の周波数が得られる厚みだけ水晶基板表面を切削するのである。

【００４０】以上述べたいずれの方法でも、チャンバーを開閉せずに１バッチの工程で基板内のＳＡＷデバイスについて周波数調整を行うことができる。

【００４１】具体的には、本発明は以下のような手段を採用している。

【００４２】第１の本発明は、圧電基板上に形成された弾性表面波デバイスを製造する際に前記弾性表面デバイスの中心周波数を調整する方法において、当該弾性表面

波デバイスの周波数特性を含む入出力特性を測定可能な端子を有するチャンバー内に前記圧電基板を配置する配置ステップと、前記弾性表面波デバイスを構成する交差指状電極の表面をドライエッチング等の方法を用いて削るエッチングステップと、前記交差指状電極の表面に酸化物を形成する酸化物形成ステップと、前記端子を介して前記弾性表面波デバイスの周波数特性を含む入出力特性の測定を行い、所望の特性が得られるまで、前記エッチングステップと前記酸化物形成ステップとを、繰り返し実行する繰り返しステップと、を含むことを特徴とする弾性表面波デバイスの中心周波数調整方法である。

【００４３】また、第２の本発明は、第１の本発明の方法を用いた弾性表面波デバイスの製造方法である。

【００４４】また、第３の本発明は、第１の本発明の方法を用いて製造された弾性表面波デバイスである。

【００４５】また、第４の本発明は、第１の本発明の方法を用いて製造された弾性表面波デバイスを利用した通信装置である。

【００４６】

【発明の実施の形態】以下、本発明の好適な実施の形態を図面に基づいて説明する。

【００４７】実施の形態1

図2には、ＳＡＷデバイスの中心周波数調整の様子を表す説明図が示されている。

【００４８】この図に示されているように、後述する図4に示すＳＡＷデバイスの電極パターンの形成された圧電基板５０をチャンバー５２に装着する。そして、チャンバー５２内にガスを導入し、プラズマを発生させる。チャンバー５２内には圧電基板５０の支持台６２が設けられている。この支持台６２は石英板を用いて形成されている。また、支持台６２の下方には金属性のプラス電極５１が取り付けられており、このプラス電極５１にＲＦ電源の出力がコンデンサを介して接続されるようになっている。一方、圧電基板５０の上方には接地されたグランド電極５３が上記プラス電極５１と平行するように取り付けられている。こうして、ＲＦ電源により高周波電圧をプラス電極５１及びグランド電極５３に印加することにより、プラズマ中で生成したイオンを電界で加速し、圧電基板５０に対して異方性エッチングすることができるようになっている。

【００４９】チャンバー５２の下部にはＳＡＷデバイスの電気特性を測定するための同軸線路が貫通する構造が設けられている。ＳＡＷデバイスには図4に示すように同軸線路先端部の端子が接触するためのパッドパターン６０が予め設けられている。先端への接触は圧電基板５０の支持台６２に固定された先端部の測定端子７０の位置を可変して調整する。そのための測定端子７０の位置調整つまみ６４が支持台６２に設けられている。先端部の測定端子７０の位置調整はチャンバー５２を開けた状態にて予め行っておく。すなわち、先端部の測定端子７０がＳＡＷ電極測定用パッドパターン６０（図４参照）に接触し電気特性測定できるようにしておくのである。

【００５０】圧電基板５０を支持台６２に装着した後、チャンバー５２の筐体の蓋部６６を閉め、チャンバー５２内の排気を行う。チャンバー５２内がある程度の真空度に達したら、初めに電極表面を酸化させるためのガスを導入する。ガスはオゾンなどの、電極材料であるアルミニウムに対して酸化反応をするものを選択する。このようなガスをチャンバー５２内に導入したら支持台６２に装着された温度調節器（図示せず）を駆動し、圧電基板５０を加熱する。圧電基板５０を加熱することによって、電極表面の酸化反応を促進させ、短時間で目的の厚さの酸化膜を形成することができる。温度調節器は従来技術を用いて構成することができるが、例えば支持台６２或いはプラス電極５１にパイプを埋設し、該パイプに熱交換媒体を流通させればよい。

【００５１】形成する酸化膜の厚みは、そのＳＡＷデバイスの使用環境温度で決まる酸化膜厚以上であって、その使用環境温度でそれ以上酸化が進行しないような酸化膜厚とする。酸化膜形成が終了したら、中心周波数測定を行う。このとき測定される中心周波数を、そのデバイスのｆ０基準値と呼ぶ。このように、酸化膜を形成してから中心周波数の測定を行うことによって、安定したｆ０（中心周波数）の測定値を得ることができる。

【００５２】このようにして基準ｆ０測定が終了した後、チャンバー５２内を排気し、今度は塩素系ガスをチャンバー５２内に導入する。ガスの導入後、ＲＦ電力を印加し、ドライエッチング処理を行う。ドライエッチング処理の際のＲＦ電力やガス濃度に関する最適な条件は、あらかじめ検査して求めておく。その最適な条件の下でドライエッチング処理を行う。エッチング量の制御はＲＦ電力印加時間等で行う。エッチングにより中心周波数は高くなる。エッチング時間は目的の中心周波数を越えないよう、短めに設定する。

【００５３】ドライエッチング処理が終了したら排気し、再度酸化膜形成を行う。目的の酸化膜厚が得られたら、再び中心周波数測定を行う。目的の周波数に達していない場合更に排気し、上記ドライエッチング及び酸化膜形成の工程を繰り返す。目的の中心周波数が得られたら排気し基板を取り出す。

【００５４】このように図２に示す構造のチャンバー５２を用いて常に一定の酸化膜を形成しながら、周波数測定を行う。

【００５５】上記のように、本実施の形態は、１バッチ内でｆ０調整、周波数安定化（酸化膜形成）、周波数測定、を繰り返し処理する。したがって、恒久的な周波数測定作業を行うことが可能となる。又、繰り返し処理ができることから、ドライエッチング処理は初めは大ざっぱに行い（すなわちエッチング量を大きく設定し）、中心周波数が目的周波数に近づいたら、処理条件を変更

し、微調整をする（すなわちエッチング量を小さな値にする）ことができる。そのため、処理を、短時間で、かつ正確に行うことが可能である。

【0056】本実施の形態によれば、ＳＡＷデバイスの中心周波数を直接測定しているので、ガスやチャンバー５２内の状況が変化しても、誤ったエッチング処理をし、目的周波数と大きく異なった周波数に調整してしまう恐れがない。

【0057】また、本実施の形態によれば、酸化膜の形成を行っているため、その後の時間経過での周波数変移を防止することができる。したがって、経年変化による周波数変動を考慮する必要がなくなる。

【0058】実施の形態２

図３には、他の実施の形態における中心周波数の調整の様子を表す説明図が示されている。

【0059】図３に示されているように、ＳＡＷデバイスはウェハー状態でなく、ダイシングされ、フリップチップ実装されている。すなわち上述した図６に示すような形態で支持されている。

【0060】フリップチップ実装においては、必ずＳＡＷチップ１０とパッケージ１２との間に金バンプ１４の高さ分の空間が空いている。金バンプ１４を利用したフリップチップ型弾性表面波デバイスの場合にはおよそ３０μｍの空隙が空いている。又、ＳＡＷチップ１０の辺縁部とパッケージ１２との間にもおよそ５０μｍの空間が空いている。上述したように、励起活性種はパッケージ１２とＳＡＷチップ１０の空間を通ってチップ電極表面に達する。その結果、ＳＡＷチップ１０の表面の弾性波伝搬領域上の物質がエッチングされる。測定端子７０は支持台６２の表 からパッケージ１２のパターンに接触し、電気測定が可能であ る。すなわち、支持台６２には高周波同軸線路挿通用の小孔が二つ設けられており、測定端子７０は該小孔を通じてパッケージ１２のパターンに夫々接触するようになっている。そして、測定端子７０の位置を微調整することによって良好な接触が達成される。

【0061】このように、チャンバー５２内にチップの実装されたパッケージ１２を装着、排気、ドライエッチング、排気、電極酸化、電気特性測定を行っても、上記実施の形態１と同様の効果が得られる。

【0062】

【発明の効果】以上述べたように、本発明によれば、時間と共に進行する自然酸化膜の影響に留意する必要がなく、ＳＡＷデバイスの正確な中心周波数調整が可能である。本発明においては酸化膜を予め調整段階で形成するため、長期的に性能が安定したデバイスを得ることができる製造方法が提供可能であ る。

【0063】さらに、本発明によれば、ＲＦ測定、ｆ０調整（電極エッチング）、ｆ０安定化（酸化膜形成）を同時に単一の装置で行うため、工程数、コスト削減を実現することが可能であ る。

【図面の簡単な説明】

【図１】　本実施の形態１におけるＳＡＷデバイスの中心周波数の調整動作の説明図であ る。

【図２】　本実施の形態１におけるＳＡＷデバイスの中心周波数の調整を行う動作を説明する説明図であ る。

【図３】　本実施の形態２におけるＳＡＷデバイスの中心周波数の調整を行う動作を説明する説明図であ る。

【図４】　本実施の形態１における、測定用パッドパターンを含むチップパターンを表す説明図であ る。

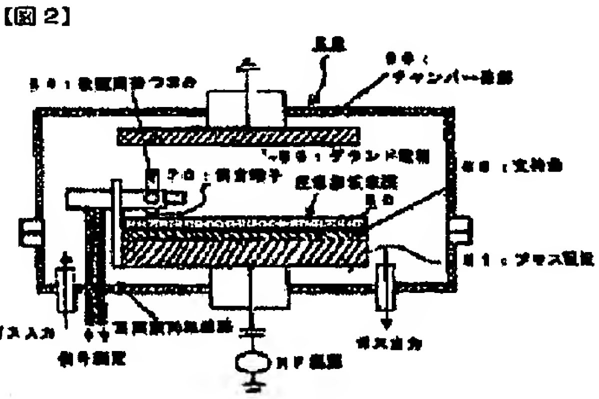
【図５】　従来のＦＤＢ方式のＳＡＷフィルタ製造方法を表す説明図であ る。

【図６】　従来のＳＡＷフィルタの製造工程を表すフローチャートであ る。

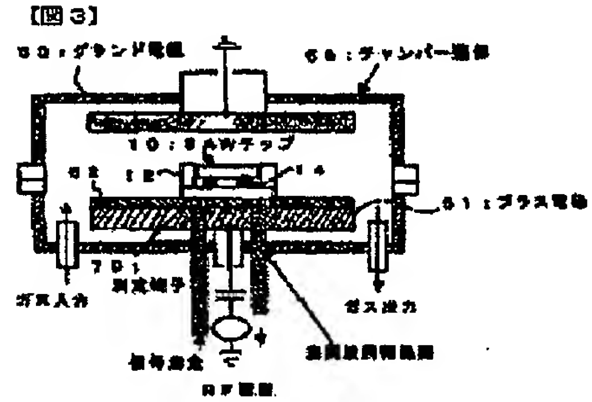
【符号の説明】

１０　ＳＡＷチップ、１２　パッケージ、１４　金バンプ、２０　ウェハー・プロセス、２２　アッセンブリー・プロセス、５０　圧電基板、５１　プラス電極、５２　チャンバー、５３　グランド電極、６０　測定用パッドパターン、６２　支持台（石英板）、６４　位置調整つまみ、６６　蓋部、７０　測定端子。

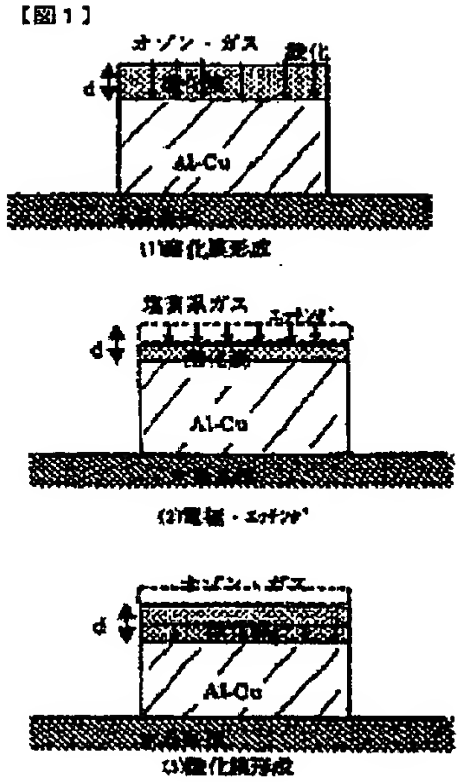
【図２】



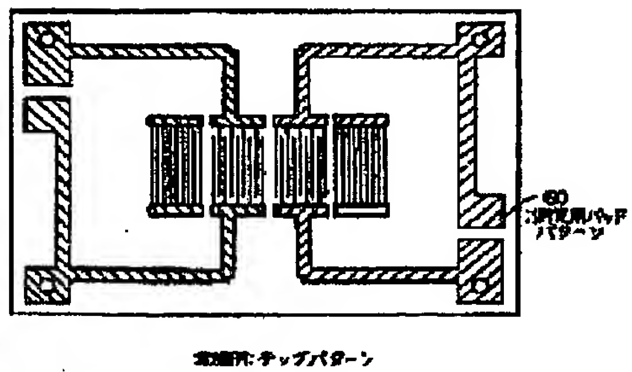
【図３】



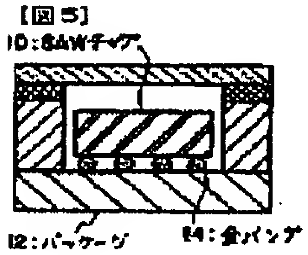
【図1】



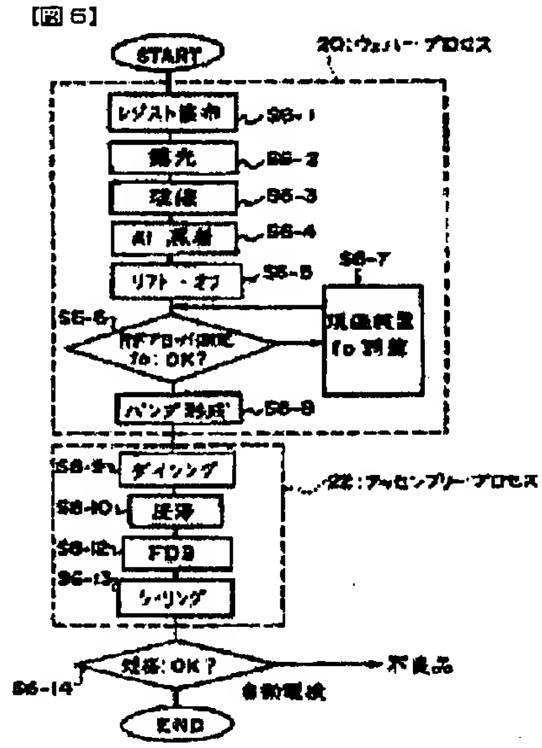
【図4】



【図5】



【図6】


START
20:ウェハープロセス
S6-1
S6-2
S6-3
S6-4
S6-5
S6-7
S6-6
fo:OK?
S6-8
S6-9
22:アッセンブリープロセス
S6-10
FD8
S6-12
S6-13
S6-14
不良品
END

* NOTICES *

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] In the approach of adjusting the center frequency of said elastic surface device in case the surface acoustic wave device formed on the piezo-electric substrate is manufactured The arrangement step which arranges said piezo-electric substrate in the chamber which has a measurable terminal for input-output behavioral characteristics including the frequency characteristics of the surface acoustic wave device concerned, The etching step which deletes the front face of the crossover finger-like electrode which constitutes said surface acoustic wave device using approaches, such as dry etching, Until it measures the oxide formation step which forms oxide in the front face of said crossover finger-like electrode, and the input-output behavioral characteristics which include the frequency characteristics of said elastic surface device through said terminal and a desired property is acquired The center frequency adjustment approach of the surface acoustic wave device characterized by including the repeat step which repeats and performs said etching step and said oxide formation step.
[Claim 2] The manufacture approach of the surface acoustic wave device using the approach of claim 1.
[Claim 3] The surface acoustic wave device manufactured using the approach of claim 1.
[Claim 4] The communication device using the surface acoustic wave device manufactured using the approach of claim 1.

[Translation done.]

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to a SAW (surface acoustic wave) device. It is related with the approach of adjusting the center frequency of the SAW device into a production process especially.
[0002]
[Description of the Prior Art] The SAW device is widely used as a frequency filter. Invention-in-this-application persons are developing the filter using the Xtal base which narrow-band-ized the resonance frequency more.
[0003] This RF narrow band filter currently developed is a high Q resonator filter using STW on the Xtal substrate (Surface Transverse Wave), and the acoustic velocity of those surface acoustic waves is 5100 m/s extent, and is suitable for a high speed and RF-ization compared with the conventional device. The load Q value of this device currently developed is about about 1500. Moreover, since the Xtal substrate is used for this STW device, it presents the frequency temperature characteristic of about 1-4 ppm/degree C to the frequency temperature dependence property of -18 ppm/degree C of the conventional SAW device. Consequently, as for the developed STW device, a frequency drift serves as about 100 ppm (0.08MHz) extent to a 100-degree C temperature requirement.
[0004] Since it has high Q value, this developed STW device is set to about 0.5MHz to that pass band width having been about 2.4MHz conventionally for example, with a 800MHz band filter. That is, super-narrow-band-ization is attained to the conventional SAW device. In addition, the fractional band width of the developed STW device is 0.07%. Moreover, similarly the magnitude of attenuation out of band is set to 35dB by **2MHz of center frequency to the conventional device having been 20dB in **2MHz of center frequency, and the extensive improvement is realized. Moreover, the application to VCO etc. is also possible for this developed STW device as a high Q resonator.
[0005] Since the acoustic velocity of a surface acoustic wave is quick, in the developed STW device, a 1GHz signal is treated and it is about 1.3 micrometers in electrode line breadth. Therefore, under a current electrode processing technique, manufacture of the filter which can treat even about 1-2GHz as signal frequency is possible.
[0006] However, in this STW device that invention-in-this-application persons have developed, completion dimension variations, such as electrode digital-furrow width of face and electrode layer thickness, became a problem for high Q value and narrow pass band width. Fluctuation of the center of filter frequency especially by electrode layer thickness variation brought a result to which the manufacture yield is reduced greatly.
[0007] The sensibility of the center frequency by the electrode layer thickness of this STW device is 0.2MHz / about 10A. Moreover, aluminum (aluminum) vacuum evaporationo equipment manufacture precision is 30A - about 60A. Consequently, a maximum of about 1.2MHz of center frequency may be changed. At the conventional SAW filter, although some fluctuation of such center frequency is extent which influences the yield, it also has a possibility that a passband may completely become a different thing, with the Xtal STW filter developed newly as a result of fluctuation of center frequency. Therefore, the situation where one piece does not exist [the filter with which the target frequency characteristics are acquired] in 1 wafer (or inside of 1 batch), either is also fully assumed.
[0008] Therefore, invention-in-this-application persons needed to investigate fluctuation of the center frequency by the marginal process tolerance of the vacuum evaporationo equipment which was not made an issue of until now, and the film production variation condition (electrode layer thickness, electrode digital-furrow width of face) about the newly developed STW device, and needed to establish the technique of adjusting the center frequency.
[0009] The explanatory view showing the SAW filter manufacture approach of the conventional FDB method is shown

in FDB manufacture method drawing 5 . A FDB method is the manufacture approach of connecting with a SAW chip I/O pad the pattern formed in the interior of the package 12 which contains the SAW chip 10 through the facing-each-other golden bump 14, and performing electric connection and mechanical maintenance to coincidence.
[0010] This manufacture approach has a stable package internal state in order not to use adhesives etc., and it is suitable for manufacture of the various narrow-band SAW filters containing the above-mentioned Xtal STW filter. Moreover, since a SAW device can be miniaturized, it is mostly used for a mass-production form.
[0011] The present manufacture approach and the production process of the adjustment approach SAW filter of center frequency can roughly be divided into the wafer process of the first half, and the assembly process of the second half. The flow chart showing this production process is shown in drawing 6 .
[0012] In the wafer process 20, an electrode pattern, pad pattern formation, other substrate surface treatment, etc. are performed on a piezo-electric substrate. Resist spreading is performed in step S6-1, and exposure and development are performed in step S6-2 and step S6-3. Moreover, aluminum vacuum evaporationo is performed in step S6-4. Furthermore, a lift-off activity is done in step S6-5. These processings of each are performed for every pattern.
[0013] Since the vacuum evaporationo thickness of an electrode pattern influences the frequency characteristics of a filter directly, control of thickness is important. The technique formed with thousands of A high degree of accuracy of **40A is known. In the conventional SAW device, pass band width was about 2.4MHz, and although the manufacture yield was bad, there was little need for frequency regulation. However, with the above-mentioned Xtal STW filter which this invention persons are developing, since ********** is realized extremely, the process for adjusting a frequency must be included in a production process.
[0014] Step S In 6-6, when inspection of center frequency f0 is conducted and it is judged that center frequency f0 needs to be adjusted, adjustment of center frequency f0 is performed in step S6-7. And bump formation is performed in step S6-8.
[0015] Next, assembly of a SAW chip is performed in the assembly process 22. Dicing is performed in step S6-9. Moreover, chip washing is performed in step S6-10. Moreover, processing of FDB(s), such as package stuffing, is performed in step S6-12. Finally sealing processing is performed in step S6-13.
[0016] Inspection of a final product is conducted in step S6-14, and what passed inspection is shipped.
[0017] As stated above, drawing 6 is the flow chart which showed the production process of the Xtal STW filter, and RF prober measurement process and f0 adjustment process are added to the production process of the conventional SAW. f0 adjustment mentioned above is performed by an RIE system (dry etching) or the developer (wet etching). Since a process increases, a manufacturing cost increases.
[0018] Frequency regulation is performed for every wafer. every chip -- **** -- now, things are difficult. Adjustment of a frequency is performed by deleting the electrode or the piezo-electric substrate front face of all chips in 1 wafer very small. Reactive-ion-etching (RIE) equipment is the most accurate, and an adjusting device has little manufacture variation. This equipment performs frequency regulation by the approach of shaving an electrode material (aluminum-Cu) using chlorine-based gas. In the wafer process 20, the equipment which develops a resist is diverted and there is also a method of performing wet etching and deleting an electrode surface. Although this approach of manufacture precision variation etc. is large, since it is simple, frequency regulation is performed in the actual site using this equipment in many cases.
[0019] The above-mentioned RIE system fits accurate frequency regulation. The trouble of this equipment is how far to be able to drop an etching rate. On the other hand, although wet etching is inferior about the homogeneity and repeatability of adjustment, for the reason mentioned above, several 10A - about 100A of electrodes is shaved using a wet etch station in practice, and about 2MHz [a maximum of] frequency regulation is performed.
[0020] Now, as stated above, there was wet etching or a dry etching technique as center frequency adjustment technique of the SAW device formed on the piezo-electric substrate.
[0021] For example, the approach using the etching reagent which diluted fluoric acid, a nitric acid, etc. is common to the wet etching of aluminum (aluminum). An organic alkali system developer can also be used for carrying out minute amount etching. Electrode thickness is made thin by etching an electrode material, and the center frequency of a component is raised.
[0022] Moreover, as dry etching, the reactive-ion-etching (RIE) technique is used widely. An electrode material and a chlorine gas system are made to react within RF electric field. Center frequency can be raised by etching an electrode material.

[0023]
[Problem(s) to be Solved by the Invention] Now, when a surface acoustic wave device is RF-ized more than a 800MHz band, IDT electrode width of face becomes as narrow [1 micrometer and electrode layer thickness] as 100nm or less, and a thickness control technique about 10A or less is needed further. In this case, the process tolerance of an electrode influences the center frequency of a device. Furthermore, it is necessary to also pay attention to the oxidation phenomenon of an electrode surface. The reason is that the thickness of an oxide film influences the center frequency of a device. Furthermore, a technique of adjusting a frequency more correctly is also desired.
[0024] Moreover, since an oxidation phenomenon advances gradually, center frequency measurement on a wafer must be performed where the above-mentioned oxide film is stabilized. If it measures while it has been unstable, it will also be assumed that center frequency changes with next oxidation phenomena in the time of measurement and product shipment in an erector.
[0025] The manufacture approach of the conventional technique mentioned above and the adjustment approach of a frequency are the single processes of sentiment (dry) etching activity -> center frequency measurement, and are not repeatedly performed on the character of an activity. The accuracy of control of the amount of etching is needed.
[0026] Especially wet etching has a bad controllability in order to make an etching reagent corrode a substrate. If it returns, frequency change is large and the activity with which center frequency is doubled with a desired frequency is difficult. Moreover, since it is not taken into consideration at all about formation of an oxide film, secular change of center frequency may arise. Specifically, the following can be said.
[0027] The electrode finger of an SAW filter is formed by the approach of carrying out vacuum deposition of aluminum-Cu. aluminum reacts chemically with the oxygen in air, and serves as an oxidation compound. The thickness of an oxidization compound increases gradually with time amount, and if it reaches a certain thickness determined with the ambient temperature of a device, it will not advance any more. This thickness is considered to be several angstroms - 100A.
[0028] As mentioned above, this oxidation reaction advances gradually after manufacture of an SAW filter, and the oxide-film thickness of an electrode surface changes. If oxide thickness changes, a center of filter frequency will also shift. In the Prior art, although there were few products with the need of taking into consideration the effect of the property on this oxide film, the adjustment technique of center frequency in which the effect on this property was taken into consideration is desired as narrow-band-ization of an SAW filter advances.
[0029] This invention is made in view of the above-mentioned technical problem, and is that the purpose can adjust the center frequency of an SAW filter easily, and secular change of center frequency offer the adjustment approach of small center frequency.
[0030]
[Means for Solving the Problem] This invention is performed by etching an aluminum-Cu electrode for f0 adjustment using chlorine-based gas using an RIE system, in order to solve the above-mentioned technical problem. And this invention proposes the new frequency regulation approach in consideration of the effect of an oxide film.
[0031] As mentioned above, fluctuation of the center frequency to thickness has the sensibility of 0.2MHz / about 10A. Even if number + angstrom extent and the thickness of an oxide film change, center frequency will shift delicately under the effect. Moreover, if control and management of oxide film thickness are not carried out but natural formation of the oxide film is carried out, center frequency will age and it will have big effect on the dependability of a device. Moreover, if an oxide film layer and an aluminum layer are etched ranging over the time of electrode etching, since the properties of an ingredient differ, an etching rate changes, and exact etching is difficult.
[0032] In order to prevent secular change, the easiest solution forms the oxide film of an electrode intentionally. The approach of raising substrate temperature in ozone gas for forming an oxide film is desirable. Since Above RIE is gas and a method made to react within a chamber, formation of an oxide film is easily possible for it by replacing gas with ozone. And it can work within this batch and is desirable on a production process.
[0033] About the electrode finger of the SAW filter arranged inside a RIE etching manufacture chamber, drawing which carried out the enlarged display of the cross section is shown in drawing 1 .
[0034] The explanatory view about formation of an oxide film is shown in drawing 1 (1). Ozone gas is first introduced in an RIE system chamber. By controlling the interior temperature of a chamber (150 degrees C - about 200 degrees C), the oxide film d more than the natural oxidation thickness decided by operating environment temperature of a device is formed beforehand. RF measurement performs center frequency measurement after formation, and the amount of

etching (cutting thickness) from which the target frequency is obtained is determined.
[0035] Next, in drawing 1 (2), exchange is performed for the gas in a chamber with chlorine-based gas, the gas concentration of an RIE system, RF power, etching time, etc. are controlled, and it etches to the target thickness. Etching thickness is ****ed within the oxide thickness created by formation of the oxide film explained by drawing 1 (1). When needing to be cut beyond it, it carries out by repeating the process to drawing 1 (1) and drawing 1 (3) described below from drawing 1 (2).
[0036] Next, in drawing 1 (3), ozone gas is again introduced in a chamber and oxide-film formation is performed. Formation of this oxide film is performed in order to compensate the oxide-film thickness for the electrode layer thickness cut by RIE. Let the oxide film obtained by formation of this oxide film be the same thickness as the oxide-film thickness formed in the processing explained by drawing 1 (1) mentioned above. Consequently, even if it takes out a device and leaves it out of a chamber, fluctuation of the center frequency of the device after electrode etching can be prevented, and the adjusted center frequency is maintained.
[0037] Electrode etching and center frequency adjustment which minded electrode oxide film effect by the above approach can be performed.
[0038] Moreover, when it is not able to adjust to the target center frequency and it adjusts still more correctly, and etching more than oxide film thickness, it is desirable to repeat again actuation of said drawing 1 (1) thru/or drawing 1 (3), and to perform it.
[0039] Moreover, center frequency can be lowered, if it not only raises center frequency, but it changes reactant gas to a fluorine system and the Xtal substrate front face is etched. When etching the Xtal substrate front face by fluorine system gas, since electrode oxide-film thickness does not change, it does not need to form an oxide film again. That is, down stream processing explained by drawing 1 (1) and drawing 1 (3) changes reactant gas into fluorine system gas from chlorine-based gas by down stream processing explained by drawing 1 (2), without performing, and only the thickness from which the target frequency is obtained cuts the Xtal substrate front face.
[0040] By any approach described above, frequency regulation can be performed about the SAW device in a substrate at the process of one batch, without opening and closing a chamber.
[0041] Specifically, this invention has adopted the following means.
[0042] In the approach of adjusting the center frequency of said elastic surface device in case the 1st this invention manufactures the surface acoustic wave device formed on the piezo-electric substrate The arrangement step which arranges said piezo-electric substrate in the chamber which has a measurable terminal for input-output behavioral characteristics including the frequency characteristics of the surface acoustic wave device concerned, The etching step which deletes the front face of the crossover finger-like electrode which constitutes said surface acoustic wave device using approaches, such as dry etching, Until it measures the oxide formation step which forms oxide in the front face of said crossover finger-like electrode, and the input-output behavioral characteristics which include the frequency characteristics of said elastic surface device through said terminal and a desired property is acquired It is the center frequency adjustment approach of the surface acoustic wave device characterized by including the repeat step which repeats and performs said etching step and said oxide formation step.
[0043] Moreover, the 2nd this invention is the manufacture approach of a surface acoustic wave device of having used the approach of the 1st this invention.
[0044] Moreover, the 3rd this invention is the surface acoustic wave device manufactured using the approach of the 1st this invention.
[0045] Moreover, the 4th this invention is a communication device using the surface acoustic wave device manufactured using the approach of the 1st this invention.
[0046]
[Embodiment of the Invention] Hereafter, the gestalt of suitable operation of this invention is explained based on a drawing.
[0047] The explanatory view showing the situation of center frequency adjustment of a SAW device is shown in gestalt 1 drawing 2 of operation.
[0048] A chamber 52 is equipped with the piezo-electric substrate 50 with which the electrode pattern of the SAW device shown in drawing 4 mentioned later was formed as shown in this drawing. And gas is introduced in a chamber 52 and the plasma is generated. In the chamber 52, the susceptor 62 of the piezo-electric substrate 50 is formed. This susceptor 62 is formed using the quartz plate. Moreover, the metallic plus electrode 51 is attached under the susceptor

62, and the output of RF power source is connected to this plus electrode 51 through a capacitor. On the other hand, it is attached above the piezo-electric substrate 50 so that the grounded grand electrode 53 may be parallel to the above-mentioned plus electrode 51. In this way, by impressing high-frequency voltage to the plus electrode 51 and the grand electrode 53 according to RF power source, the ion generated in the plasma can be accelerated by electric field, and anisotropic etching can be carried out now to the piezo-electric substrate 50.
[0049] The structure which the coaxial track for measuring the electrical property of a SAW device penetrates is prepared in the lower part of a chamber 52. The pad pattern 60 for the terminal of a coaxial track point to contact, as shown in a SAW device at drawing 4 is formed beforehand. Adjustable [of the location of the sense terminal 70 of the point fixed to the susceptor 62 of the piezo-electric substrate 50] is carried out, and the contact to a tip adjusts it. The justification tongue 64 of the sense terminal 70 for that is formed in susceptor 62. Justification of the sense terminal 70 of a point is beforehand performed, where a chamber 52 is opened. That is, the sense terminal 70 of a point contacts the pad pattern 60 (refer to drawing 4) for SAW electrode measurement, and it can be made to carry out electrical property measurement of it.
[0050] After equipping susceptor 62 with the piezo-electric substrate 50, the covering device 66 of the case of a chamber 52 is shut, and the exhaust air in a chamber 52 is performed. If the inside of a chamber 52 reaches a certain amount of degree of vacuum, the gas for oxidizing an electrode surface first will be introduced. Gas chooses what is oxidized to the aluminum which is electrode materials, such as ozone. If such gas is introduced in a chamber 52, the thermoregulator (not shown) with which susceptor 62 was equipped will be driven, and the piezo-electric substrate 50 is heated. By heating the piezo-electric substrate 50, oxidation reaction of an electrode surface can be promoted and the oxide film of the target thickness can be formed in a short time. What is necessary is to lay a pipe under susceptor 62 or the plus electrode 51, for example, and just to circulate a heat exchange medium to this pipe, although a thermoregulator can be constituted using the conventional technique.
[0051] The thickness of the oxide film to form is more than oxidation thickness decided by operating environment temperature of the SAW device, and let it be the oxidation thickness to which oxidation does not advance any more at the operating environment temperature. If oxide-film formation is completed, center frequency measurement will be performed. The center frequency measured at this time is called f0 reference value of that device. Thus, after forming an oxide film, the measured value of fstable 0 (center frequency) can be obtained by measuring center frequency.
[0052] Thus, after criteria f0 measurement is completed, the inside of a chamber 52 is exhausted and chlorine-based gas is shortly introduced in a chamber 52. RF power is impressed after installation of gas and dry etching processing is performed. The optimal conditions about RF power and gas concentration in the case of dry etching processing are inspected beforehand, and are searched for. Dry etching processing is performed under the optimal conditions. Control of the amount of etching is performed by RF power application time amount etc. Center frequency becomes high by etching. Etching time is shorter set up so that the target center frequency may not be exceeded.
[0053] It will exhaust, if dry etching processing is completed, and oxide-film formation is performed again. If the target oxide-film thickness is obtained, center frequency measurement will be performed again. When the target frequency is not reached, it exhausts further, and the process of the above-mentioned dry etching and oxide-film formation is repeated. It will exhaust, if the target center frequency is obtained, and a substrate is taken out.
[0054] Thus, frequency measurement is performed, always forming a fixed oxide film using the chamber 52 of the structure shown in drawing 2 .
[0055] As mentioned above, the gestalt of this operation repeats and processes f0 adjustment, frequency stabilization (oxide-film formation), and frequency measurement within 1 patch. Therefore, it becomes possible to do a lasting frequency measurement activity. moreover, since repeat processing can be performed, if dry etching processing is performed roughly in the beginning (namely, the amount of etching -- large -- setting up) and center frequency approaches the purpose frequency, processing conditions will be changed and what is tuned finely (that is, the amount of etching is made into a small value) will be made. Therefore, it is possible to perform processing correctly [are a short time and].
[0056] According to the gestalt of this operation, since the center frequency of a SAW device is measured directly, even if the situation in gas or a chamber 52 changes, mistaken etching processing is carried out and there is no possibility of adjusting to the purpose frequency and a greatly different frequency.
[0057] Moreover, according to the gestalt of this operation, since the oxide film is formed, the frequency change by subsequent time amount progress can be prevented. It becomes unnecessary therefore, to take into consideration the

frequency drift by secular change.
[0058] The explanatory view showing the situation of adjustment of the center frequency in the gestalt of other operations is shown in gestalt 2 drawing 3 of operation.
[0059] A SAW device is not in a wafer condition, the dicing of it is carried out and flip chip mounting is carried out as shown in drawing 3 . That is, it is supported with the gestalt as shown in drawing 6 mentioned above.
[0060] In flip chip mounting, the golden bump's 14 space for height is surely vacant between the SAW chip 10 and the package 12. In the case of the flip chip mold surface acoustic wave device using the golden bump 14, about 30-micrometer space is vacant. Moreover, about 50-micrometer space is vacant also between the side edge of the SAW chip 10, and the package 12. As mentioned above, excitation active species reaches a chip electrode surface through the space of a package 12 and the SAW chip 10. Consequently, the matter on the elastic wave propagation field of the front face of the SAW chip 10 is etched. A sense terminal 70 contacts the pattern of a package 12 from the flesh side of susceptor 62, and electrical measurement is possible for it. That is, two stomata for RF coaxial track insertion are prepared in susceptor 62, and a sense terminal 70 contacts the pattern of a package 12 through this stoma, respectively. And good contact is attained by tuning the location of a sense terminal 70 finely.
[0061] Thus, in the package 12 with which the chip was mounted in the chamber 52, even if it performs wearing, exhaust air, dry etching, exhaust air, electrode oxidation, and electrical property measurement, the same effectiveness as the gestalt 1 of the above-mentioned implementation is acquired.
[0062]
[Effect of the Invention] As stated above, it is not necessary to regard the effect of the natural oxidation film which runs with time amount, and, according to this invention, exact center frequency adjustment of a SAW device is possible. Since an oxide film is beforehand formed in an adjustment phase in this invention, the manufacture approach that the device whose engine performance was stable in the long run can be obtained can be offered.
[0063] Furthermore, according to this invention, since single equipment performs RF measurement, f0 adjustment (electrode etching), and f0 stabilization (oxide-film formation) to coincidence, it is possible to realize a routing counter and cost reduction.

[Translation done.]

TECHNICAL FIELD

[Field of the Invention] This invention relates to a SAW (surface acoustic wave) device. It is related with the approach of adjusting the center frequency of the SAW device into a production process especially.

[Translation done.]

PRIOR ART

[Description of the Prior Art] The SAW device is widely used as a frequency filter. Invention-in-this-application persons are developing the filter using the Xtal base which narrow-band-ized the resonance frequency more.
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[0004] Since it has high Q value, this developed STW device is set to about 0.5MHz to that pass band width having been about 2.4MHz conventionally for example, with a 800MHz band filter. That is, super-narrow-band-ization is attained to the conventional SAW device. In addition, the fractional band width of the developed STW device is 0.07%. Moreover, similarly the magnitude of attenuation out of band is set to 35dB by **2MHz of center frequency to the conventional device having been 20dB in **2MHz of center frequency, and the extensive improvement is realized. Moreover, the application to VCO etc. is also possible for this developed STW device as a high Q resonator.
[0005] Since the acoustic velocity of a surface acoustic wave is quick, in the developed STW device, a 1GHz signal is treated and it is about 1.3 micrometers in electrode line breadth. Therefore, under a current electrode processing technique, manufacture of the filter which can treat even about 1-2GHz as signal frequency is possible.
[0006] However, in this STW device that invention-in-this-application persons have developed, completion dimension variations, such as electrode digital-furrow width of face and electrode layer thickness, became a problem for high Q value and narrow pass band width. Fluctuation of the center of filter frequency especially by electrode layer thickness variation brought a result to which the manufacture yield is reduced greatly.
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[0009] The explanatory view showing the SAW filter manufacture approach of the conventional FDB method is shown in FDB manufacture method drawing 5 . A FDB method is the manufacture approach of connecting with a SAW chip I/O pad the pattern formed in the interior of the package 12 which contains the SAW chip 10 through the facing-each-other golden bump 14, and performing electric connection and mechanical maintenance to coincidence.
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[0022] Moreover, as dry etching, the reactive-ion-etching (RIE) technique is used widely. An electrode material and a chlorine gas system are made to react within RF electric field. Center frequency can be raised by etching an electrode material.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] As stated above, it is not necessary to regard the effect of the natural oxidation film which runs with time amount, and, according to this invention, exact center frequency adjustment of a SAW device is possible. Since an oxide film is beforehand formed in an adjustment phase in this invention, the manufacture approach that the device whose engine performance was stable in the long run can be obtained can be offered.
[0063] Furthermore, according to this invention, since single equipment performs RF measurement, f0 adjustment (electrode etching), and f0 stabilization (oxide-film formation) to coincidence, it is possible to realize a routing counter and cost reduction.

[Translation done.]

* NOTICES *

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] Now, when a surface acoustic wave device is RF-ized more than a 800MHz band, IDT electrode width of face becomes as narrow [1 micrometer and electrode layer thickness] as 100nm or less, and a thickness control technique about 10A or less is needed further. In this case, the process tolerance of an electrode influences the center frequency of a device. Furthermore, it is necessary to also pay attention to the oxidation phenomenon of an electrode surface. The reason is that the thickness of an oxide film influences the center frequency of a device. Furthermore, a technique of adjusting a frequency more correctly is also desired.
[0024] Moreover, since an oxidation phenomenon advances gradually, center frequency measurement on a wafer must be performed where the above-mentioned oxide film is stabilized. If it measures while it has been unstable, it will also be assumed that center frequency changes with next oxidation phenomena in the time of measurement and product shipment in an erector.
[0025] The manufacture approach of the conventional technique mentioned above and the adjustment approach of a frequency are the single processes of sentiment (dry) etching activity -> center frequency measurement, and are not repeatedly performed on the character of an activity. The accuracy of control of the amount of etching is needed.
[0026] Especially wet etching has a bad controllability in order to make an etching reagent corrode a substrate. If it returns, frequency change is large and the activity with which center frequency is doubled with a desired frequency is difficult. Moreover, since it is not taken into consideration at all about formation of an oxide film, secular change of center frequency may arise. Specifically, the following can be said.
[0027] The electrode finger of an SAW filter is formed by the approach of carrying out vacuum deposition of aluminum-Cu. aluminum reacts chemically with the oxygen in air, and serves as an oxidation compound. The thickness of an oxidization compound increases gradually with time amount, and if it reaches a certain thickness determined with the ambient temperature of a device, it will not advance any more. This thickness is considered to be several angstroms - 100A.
[0028] As mentioned above, this oxidation reaction advances gradually after manufacture of an SAW filter, and the oxide-film thickness of an electrode surface changes. If oxide thickness changes, a center of filter frequency will also shift. In the Prior art, although there were few products with the need of taking into consideration the effect of the property on this oxide film, the adjustment technique of center frequency in which the effect on this property was taken into consideration is desired as narrow-band-ization of an SAW filter advances.
[0029] This invention is made in view of the above-mentioned technical problem, and is that the purpose can adjust the center frequency of an SAW filter easily, and secular change of center frequency offer the adjustment approach of small center frequency.

[Translation done.]

MEANS

[Means for Solving the Problem] This invention is performed by etching an aluminum-Cu electrode for f0 adjustment using chlorine-based gas using an RIE system, in order to solve the above-mentioned technical problem. And this invention proposes the new frequency regulation approach in consideration of the effect of an oxide film.
[0031] As mentioned above, fluctuation of the center frequency to thickness has the sensibility of 0.2MHz / about 10A. Even if number + angstrom extent and the thickness of an oxide film change, center frequency will shift delicately under the effect. Moreover, if control and management of oxide film thickness are not carried out but natural formation of the oxide film is carried out, center frequency will age and it will have big effect on the dependability of a device. Moreover, if an oxide film layer and an aluminum layer are etched ranging over the time of electrode etching, since the properties of an ingredient differ, an etching rate changes, and exact etching is difficult.
[0032] In order to prevent secular change, the easiest solution forms the oxide film of an electrode intentionally. The approach of raising substrate temperature in ozone gas for forming an oxide film is desirable. Since Above RIE is gas and a method made to react within a chamber, formation of an oxide film is easily possible for it by replacing gas with ozone. And it can work within this batch and is desirable on a production process.
[0033] About the electrode finger of the SAW filter arranged inside a RIE etching manufacture chamber, drawing which carried out the enlarged display of the cross section is shown in drawing 1 .
[0034] The explanatory view about formation of an oxide film is shown in drawing 1 (1). Ozone gas is first introduced in an RIE system chamber. By controlling the interior temperature of a chamber (150 degrees C - about 200 degrees C), the oxide film d more than the natural oxidation thickness decided by operating environment temperature of a device is formed beforehand. RF measurement performs center frequency measurement after formation, and the amount of etching (cutting thickness) from which the target frequency is obtained is determined.
[0035] Next, in drawing 1 (2), exchange is performed for the gas in a chamber with chlorine-based gas, the gas concentration of an RIE system, RF power, etching time, etc. are controlled, and it etches to the target thickness. Etching thickness is ****ed within the oxide thickness created by formation of the oxide film explained by drawing 1 (1). When needing to be cut beyond it, it carries out by repeating the process to drawing 1 (1) and drawing 1 (3) described below from drawing 1 (2).
[0036] Next, in drawing 1 (3), ozone gas is again introduced in a chamber and oxide-film formation is performed. Formation of this oxide film is performed in order to compensate the oxide-film thickness for the electrode layer thickness cut by RIE. Let the oxide film obtained by formation of this oxide film be the same thickness as the oxide-film thickness formed in the processing explained by drawing 1 (1) mentioned above. Consequently, even if it takes out a device and leaves it out of a chamber, fluctuation of the center frequency of the device after electrode etching can be prevented, and the adjusted center frequency is maintained.
[0037] Electrode etching and center frequency adjustment which minded electrode oxide film effect by the above approach can be performed.
[0038] Moreover, when it is not able to adjust to the target center frequency and it adjusts still more correctly, and etching more than oxide film thickness, it is desirable to repeat again actuation of said drawing 1 (1) thru/or drawing 1 (3), and to perform it.
[0039] Moreover, center frequency can be lowered, if it not only raises center frequency, but it changes reactant gas to a fluorine system and the Xtal substrate front face is etched. When etching the Xtal substrate front face by fluorine system gas, since electrode oxide-film thickness does not change, it does not need to form an oxide film again. That is,

down stream processing explained by drawing 1 (1) and drawing 1 (3) changes reactant gas into fluorine system gas from chlorine-based gas by down stream processing explained by drawing 1 (2), without performing, and only the thickness from which the target frequency is obtained cuts the Xtal substrate front face.

[0040] By any approach described above, frequency regulation can be performed about the SAW device in a substrate at the process of one batch, without opening and closing a chamber.

[0041] Specifically, this invention has adopted the following means.

[0042] In the approach of adjusting the center frequency of said elastic surface device in case the 1st this invention manufactures the surface acoustic wave device formed on the piezo-electric substrate The arrangement step which arranges said piezo-electric substrate in the chamber which has a measurable terminal for input-output behavioral characteristics including the frequency characteristics of the surface acoustic wave device concerned, The etching step which deletes the front face of the crossover finger-like electrode which constitutes said surface acoustic wave device using approaches, such as dry etching, Until it measures the oxide formation step which forms oxide in the front face of said crossover finger-like electrode, and the input-output behavioral characteristics which include the frequency characteristics of said elastic surface device through said terminal and a desired property is acquired It is the center frequency adjustment approach of the surface acoustic wave device characterized by including the repeat step which repeats and performs said etching step and said oxide formation step.

[0043] Moreover, the 2nd this invention is the manufacture approach of a surface acoustic wave device of having used the approach of the 1st this invention.

[0044] Moreover, the 3rd this invention is the surface acoustic wave device manufactured using the approach of the 1st this invention.

[0045] Moreover, the 4th this invention is a communication device using the surface acoustic wave device manufactured using the approach of the 1st this invention.

[0046]

[Embodiment of the Invention] Hereafter, the gestalt of suitable operation of this invention is explained based on a drawing.

[0047] The explanatory view showing the situation of center frequency adjustment of a SAW device is shown in gestalt 1 drawing 2 of operation.

[0048] A chamber 52 is equipped with the piezo-electric substrate 50 with which the electrode pattern of the SAW device shown in drawing 4 mentioned later was formed as shown in this drawing. And gas is introduced in a chamber 52 and the plasma is generated. In the chamber 52, the susceptor 62 of the piezo-electric substrate 50 is formed. This susceptor 62 is formed using the quartz plate. Moreover, the metallic plus electrode 51 is attached under the susceptor 62, and the output of RF power source is connected to this plus electrode 51 through a capacitor. On the other hand, it is attached above the piezo-electric substrate 50 so that the grounded grand electrode 53 may be parallel to the above-mentioned plus electrode 51. In this way, by impressing high-frequency voltage to the plus electrode 51 and the grand electrode 53 according to RF power source, the ion generated in the plasma can be accelerated by electric field, and anisotropic etching can be carried out now to the piezo-electric substrate 50.

[0049] The structure which the coaxial track for measuring the electrical property of a SAW device penetrates is prepared in the lower part of a chamber 52. The pad pattern 60 for the terminal of a coaxial track point to contact, as shown in a SAW device at drawing 4 is formed beforehand. Adjustable [of the location of the sense terminal 70 of the point fixed to the susceptor 62 of the piezo-electric substrate 50] is carried out, and the contact to a tip adjusts it. The justification tongue 64 of the sense terminal 70 for that is formed in susceptor 62. Justification of the sense terminal 70 of a point is beforehand performed, where a chamber 52 is opened. That is, the sense terminal 70 of a point contacts the pad pattern 60 (refer to drawing 4) for SAW electrode measurement, and it can be made to carry out electrical property measurement of it.

[0050] After equipping susceptor 62 with the piezo-electric substrate 50, the covering device 66 of the case of a chamber 52 is shut, and the exhaust air in a chamber 52 is performed. If the inside of a chamber 52 reaches a certain amount of degree of vacuum, the gas for oxidizing an electrode surface first will be introduced. Gas chooses what is oxidized to the aluminum which is electrode materials, such as ozone. If such gas is introduced in a chamber 52, the thermoregulator (not shown) with which susceptor 62 was equipped will be driven, and the piezo-electric substrate 50 is heated. By heating the piezo-electric substrate 50, oxidation reaction of an electrode surface can be promoted and the oxide film of the target thickness can be formed in a short time. What is necessary is to lay a pipe under susceptor 62 or

the plus electrode 51, for example, and just to circulate a heat exchange medium to this pipe, although a thermoregulator can be constituted using the conventional technique.
[0051] The thickness of the oxide film to form is more than oxidation thickness decided by operating environment temperature of the SAW device, and let it be the oxidation thickness to which oxidation does not advance any more at the operating environment temperature. If oxide-film formation is completed, center frequency measurement will be performed. The center frequency measured at this time is called f0 reference value of that device. Thus, after forming an oxide film, the measured value of fstable 0 (center frequency) can be obtained by measuring center frequency.
[0052] Thus, after criteria f0 measurement is completed, the inside of a chamber 52 is exhausted and chlorine-based gas is shortly introduced in a chamber 52. RF power is impressed after installation of gas and dry etching processing is performed. The optimal conditions about RF power and gas concentration in the case of dry etching processing are inspected beforehand, and are searched for. Dry etching processing is performed under the optimal conditions. Control of the amount of etching is performed by RF power application time amount etc. Center frequency becomes high by etching. Etching time is shorter set up so that the target center frequency may not be exceeded.
[0053] It will exhaust, if dry etching processing is completed, and oxide-film formation is performed again. If the target oxide-film thickness is obtained, center frequency measurement will be performed again. When the target frequency is not reached, it exhausts further, and the process of the above-mentioned dry etching and oxide-film formation is repeated. It will exhaust, if the target center frequency is obtained, and a substrate is taken out.
[0054] Thus, frequency measurement is performed, always forming a fixed oxide film using the chamber 52 of the structure shown in drawing 2 .
[0055] As mentioned above, the gestalt of this operation repeats and processes f0 adjustment, frequency stabilization (oxide-film formation), and frequency measurement within 1 patch. Therefore, it becomes possible to do a lasting frequency measurement activity. moreover, since repeat processing can be performed, if dry etching processing is performed roughly in the beginning (namely, the amount of etching -- large -- setting up) and center frequency approaches the purpose frequency, processing conditions will be changed and what is tuned finely (that is, the amount of etching is made into a small value) will be made. Therefore, it is possible to perform processing correctly [are a short time and].
[0056] According to the gestalt of this operation, since the center frequency of a SAW device is measured directly, even if the situation in gas or a chamber 52 changes, mistaken etching processing is carried out and there is no possibility of adjusting to the purpose frequency and a greatly different frequency.
[0057] Moreover, according to the gestalt of this operation, since the oxide film is formed, the frequency change by subsequent time amount progress can be prevented. It becomes unnecessary therefore, to take into consideration the frequency drift by secular change.
[0058] The explanatory view showing the situation of adjustment of the center frequency in the gestalt of other operations is shown in gestalt 2 drawing 3 of operation.
[0059] A SAW device is not in a wafer condition, the dicing of it is carried out and flip chip mounting is carried out as shown in drawing 3 . That is, it is supported with the gestalt as shown in drawing 6 mentioned above.
[0060] In flip chip mounting, the golden bump's 14 space for height is surely vacant between the SAW chip 10 and the package 12. In the case of the flip chip mold surface acoustic wave device using the golden bump 14, about 30-micrometer space is vacant. Moreover, about 50-micrometer space is vacant also between the side edge of the SAW chip 10, and the package 12. As mentioned above, excitation active species reaches a chip electrode surface through the space of a package 12 and the SAW chip 10. Consequently, the matter on the elastic wave propagation field of the front face of the SAW chip 10 is etched. A sense terminal 70 contacts the pattern of a package 12 from the flesh side of susceptor 62, and electrical measurement is possible for it. That is, two stomata for RF coaxial track insertion are prepared in susceptor 62, and a sense terminal 70 contacts the pattern of a package 12 through this stoma, respectively. And good contact is attained by tuning the location of a sense terminal 70 finely.
[0061] Thus, in the package 12 with which the chip was mounted in the chamber 52, even if it performs wearing, exhaust air, dry etching, exhaust air, electrode oxidation, and electrical property measurement, the same effectiveness as the gestalt 1 of the above-mentioned implementation is acquired.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the explanatory view of adjustment actuation of the center frequency of the SAW device in the gestalt 1 of this operation.
[Drawing 2] It is an explanatory view explaining the actuation which adjusts center frequency of the SAW device in the gestalt 1 of this operation.
[Drawing 3] It is an explanatory view explaining the actuation which adjusts center frequency of the SAW device in the gestalt 2 of this operation.
[Drawing 4] It is an explanatory view showing the chip pattern containing the pad pattern for measurement in the gestalt 1 of this operation.
[Drawing 5] It is an explanatory view showing the SAW filter manufacture approach of the conventional FDB method.
[Drawing 6] It is a flow chart showing the production process of the conventional SAW filter.
[Description of Notations]
10 A SAW chip, 12 A package, 14 A golden bump, 20 A wafer process, 22 An assembly process, 50 A piezo-electric substrate, 51 A plus electrode, 52 A chamber, 53 A grand electrode, 60 The pad pattern for measurement, 62 Susceptor (quartz plate), 64 A justification tongue, 66 A covering device, 70 Sense terminal.

[Translation done.]